TECHNICAL NOTES.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 29.

# PROGRESS MADE IN THE CONSTRUCTION OF GIANT AIRPLANES IN GERMANY DURING THE WAR.

By

A. Baumann.

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The Paris Office of the National Advisory Committee for Aeronautics prepared the following Resume of Dr. A. Baumann's paper on the "Progress Made in the Construction of Giant Airplanes in Germany during the War." Dr. Baumann's paper appeared in "Zeitschrift des Vereines Deutscher Ingenieure."

## R E S U M É

The construction of giant airplanes was begun in Germany in August, 1914. Zeppelin placed it in the hands of Mr. Baumann, who first had Mr. HIRTH, Engineer and pilot, as Technical Advisory. The Manager of the Bosch magnetos Company, Mr. Klein, also took an interest in the affair, and the construction was begun in the Gotha Wagon Factory, afterwards being transferred to the Zeppelin Works at Staaken near Berlin.

The annexed Tables give the characteristics of the machines described by the author, to which are added the LINKE-HOFFMAN airplanes, not mentioned in the article.

The Tables show that a large number of airplanes, weighing up to 15.5 tons were constructed and tested in Germany during the War, and it is certain that no other country turned out airplanes of this weight, nor in such large numbers.

It would appear, however, that only the Zeppelin Works at Staaken turned out practical airplanes which rendered service during the War.

An examination of the Tables shows that by the end of the War all the manufacturers had arrived at a well-defined type, namely, an airplane of about 12 tons with 4 engines of 260 horsepower, that is, a total of 1040 HP.

As regards the arrangement of engines and propellers, the Zeppelin Works had adopted the system of 4 engines placed in tandem between the wings and controlling the propellers directly; this system was adopted

both for their airplanes and seaplanes built at Staaken, and for their seaplanes built at Lindau. The other manufacturers preferred to place the engines in the fuselage, and to have the propellers controlled by the shaft and gear.

If we examine the question of useful weight, we see that the ratio of useful weight (fuel included) to the total weight of the airplane does not exceed 30%, which is a very low figure considering that these airplanes carried about 11 kgs. per horsepower, and which, at the present time, constitutes the limit of the load per horsepower realizable by an airplane loaded at 45 and 50 kg/sq.m, and having its ceiling at about 3,000 m. This low value is explained by the very heavy construction of the structure and by the great weight per h.p. of the engine set, which is, on an average, 2.5 kg/h.p.

On the other hand, the speed of all these airplanes does not exceed 130 km/hr. Under these conditions, we may well ask whether the results obtained correspond to the enormous output of work and money entailed by the construction of these machines, and whether better results might not have been obtained with smaller machines.

The author himself now appears to hold this opinion, for in a recent lecture on "THE DEVELOPMENT OF GIANT AIRPLANES AND THEIR IMPORTANCE FROM THE POINT OF VIEW OF AERIAL TRANSPORT" (Zeitschrift für Flugtechnik und Motorluftschiffahrt, No.3, 1920) he stated that he did not think that an increase in the size of airplanes would lead to an increase of their useful weight or of their radius of flight, and that increase of speed should rather be sought by the adoption of thick wings doing away with the need of bracing wires.

As regards the aerodynamic qualities of giant airplanes, we may remark that all these machines except the Staaken No. 6 and the Siemens No. 3, carry very heavy loads per square meter and per horsepower: from 45 to 50 kgs/sq.m. and from 10 to 12 kg/h.p. Now, their ceiling is, on an average, at 3,500 meters and computation shows that, under these conditions, the maximum value of $K_Y^{3/2}/K_X$, measuring the climbing aptitude of the machine, is very high: about 2.2, greatly in excess of this same value for small machines, where it is about 1.7.

On the other hand, from the point of view of structural resistance, giant airplanes are not good. As a matter of fact, the value of $K_X$ in horizontal flight near the ground varies between 0.003 and 0.0068 Kg/sq.m/m:sec., while for small airplanes it is 0.0025 and reaches 0.0019 for the "Goliath" (Farman).

On this point we may remark that the best value of $K_X$ is realized by the Staaken No. 6, which is also the machine having the smallest load per square meter, and which has given the best results. On this subject we may ask whether, contrary to the belief of certain authors, it is not advantageous to adopt small loads per square meter, both for giant airplanes and small machines.

ZEPPELIN WORKS AT STAAKEN NEAR BERLIN

| Constructor and Type: | No.1 1914/15 | No.2 1915/16 | No.3 1915 |
|---|---|---|---|
| ENGINES Constructor and Type: | 3 Maybach | 5 Maybach | 6 Daimler |
| Description Bore x Stroke | | | |
| H.P. r.p.m.;r.p.m. (eng) (pro) | 3 x 250 = 750 | 5 x 250 =1250 | 6 x 160 = 960 |
| DIMENSIONS (in m.) Span Length Aspect R. Height Surface (in sq.m.): | | | |
| WEIGHT, Total " Empty | | | |
| Glider | | | |
| Engine Set | | | |
| Useful Load | | | |
| Fuel Hours of Flight | 3,000 | | 3,500 |
| Maximum Speed in horizontal flight | | | |
| Climb | | | |
| Ceiling (in m.) | 3,000 | 4,500 | 3,000 |
| Kg/sq.m. | | | |
| Kg/HP | | | |
| $K_X$ in horizontal flight near ground | | | |
| $K_Y^{3/2}/K_X$ max. | | | |
| $K_Y$ maximum | | | |
| Remarks. | | Smashed before acceptance | |
| Source of information | "Zeitschrift der V.D.Ing. of May 31st and October 28th, 1919: | | |

ZEPPELIN WORKS AT STAAKEN NEAR BERLIN.

| Constructor and Type | No.4 1915 | No.5 1916 | No.6 1916/17/18 |
|---|---|---|---|
| Description | Biplane Central Fuselage | Biplane Central fuselage 1 engine in fus. 4 engines in tandem in wings 1 Central tractor propeller 2 lateral propulsive propellers | Biplane Central fuselage 4 engines in tandem in wings |
| ENGINES Constructor and Type | 4 Benz 2 Daimler | 5 Maybach | 4 Daimler |
| Description Bore x Stroke | | | |
| H.P. r.p.m.; r.p.m. (eng); (pro) | 4 x 220) 2 x 160) 1200 | 5 x 250 =1250 | 4 x 260 = 1040 1400; 700 |
| DIMENSIONS (in m.) | | | |
| Span | | | 42.2 |
| Length Aspect R. | | | 8.5 |
| Height | | | |
| Surface (in sq.m.) | | | 132 |
| WEIGHT, Total | | | 11,500 |
| " Empty | | | 8,300 |
| Glider | | | 5,900/0.61 |
| Engine Set | | | 2,400 |
| Useful Load | | | |
| Fuel Hours of Flight | 4,500 | 4,500 | 3,200 |
| Maximum Speed in horizontal flight | | | 135 |
| Climb | 4,000 | 4,000 | 3,000 in 60' |
| Ceiling (in m) | | | 3,800 |
| Kg/sq.m | | | 35 |
| Kg/HP | | | 11.5 |
| $K_X$ in horizontal flight near ground | | | 0.0031 |
| $K_Y^{3/2}/K_X$ max. | | | 2.2 |
| $K_Y$ maximum | | | |
| Remarks | | | Best known type; built in quantity production by the Staaken Works, by "Aviatik", Schütte Lanz and "Albatros" |

Source of Information: Z. des V.D.Ing. of May 31 and Oct. 28, 1919.

ZEPPELIN WORKS AT STAAKEN NEAR BERLIN

| Constructor and Type: | " No.7 1917/18 | Seaplane No.8 1917/18 | Seaplane No.9 1918 |
|---|---|---|---|
| Description | Biplane :Central fuselage :1 engine in fus. :4 eng. in tandem: in wings : 1 central prop. : 4 lateral " | Biplane 2 floats :Central fuselage: 4 eng. in tandem: | Biplane 2 floats : 1 engine in fus. :Central fuselage : 4 engines in tandem in wings |
| ENGINES Constructor and Type: | 5 Maybach | 4 Maybach | 5 |
| Description Bore x Stroke | | | |
| H.P. r.p.m.;r.p.m. (eng) (pro) | 5 x 250 =1250 | 4 x 250=1000 | 5 x 300 = 1500 |
| DIMENSIONS (in m) Span | | | |
| Length Aspect R | | | |
| Height | | | |
| Surface (in sq.m) | | | |
| WEIGHT, Total | | | |
| " Empty | | | |
| Glider | | | |
| Engine Set | | | |
| Useful Load | | | |
| Fuel Hours of Flight | 4,500 | 4,500 | 5,000 |
| Maximum Speed in HORIZONTAL FLIGHT | | | |
| Climb | | | |
| Ceiling (in m) | 4,500 | 2,500 | |
| Kg/sq.m. | | | |
| Kg/HP | | | |
| $K_X$ in horizontal flight near ground: | | | |
| $K_Y^{3/2}/K_X$ max. | | | |
| $K_Y$ maximum | | | |
| Remarks | | :This is Airplane : 6 on floats. :Built by "Avia- :tik" Works | This is Airplane 7 on floats Built by "Avia- tik Works |

Source of Information: "Zeitschrift des Vereines Deutscher Ingenieure" of May 31st and Oct. 28th, 1919.

SIEMENS-SCHUCKERT

| Constructor and Type | No.$1_1$ 1915 | No.$1_2$ 1915 | No.$2_1$ 1915 |
|---|---|---|---|
| Description | Biplane Central fuselage 4 engines in line 4 tractor propellers | | Biplane Central fuselage 2 eng. in fuselage working 2 lateral tractor propellers |
| ENGINES Constructor and Type | 4 Argus | 2 Argus 2 Mercedes | 2 Benz |
| Description Bore x Stroke | 4 vertical cyl. Water-cooled | Mercedes, 8 vertical cylinders | |
| H.P. r.p.m.;r.p.m. (eng) (pro) | 4 x 110 = 440 | 2 x 110) 660 2 x 220) | 2 x 350 = 700 1800; 900 |
| DIMENSIONS (in m) | | | |
| Span | 24 | 24 | 26 |
| Length Aspect R | | | |
| Height | | | |
| Surface (in sq.m.) | 114 | 114 | |
| WEIGHT, Total | | 5,200 | 5,200 |
| " Empty | 3,500 | 4,000 | 4,000 |
| Glider | | 2,200/0.42 | |
| Engine Set | | 1,800 | |
| Useful Load | | | |
| Fuel Hours of Flight | | 1,200 | |
| Maximum Speed in horizontal flight | | | |
| Climb | | 2,000 in 29' | 3,000 in 35' |
| Ceiling (in m) | | | |
| Kg/sq.m | | 45.6 | |
| Kg/HP | | 7.6 | |
| $K_X$ in horizontal flight near ground | | | |
| $K_Y^{3/2}/K_X$ max. | | | |
| $K_Y$ maximum | | | |
| Remarks | The constructors have taken some ideas from the Sikorsky Air[illegible] | The Army does not recommend the development of this type. | |

Source of Information: "Zeitschrift des Vereines Deutscher Ingenieure" of January 24th, 1920.

SIEMENS-SCHUCKERT

| Constructor and Type | No.$2_2$ 1915 | No.$2_3$ 1915 | No.3 1917 |
|---|---|---|---|
| Description | Biplane Central fuselage 3 eng. in fus. 2 lateral tractor propellers | | Biplane Central fuselage 6 eng. in fus. 4 pro. in tandem between wings. |
| ENGINES Constructor and Type | 3 Benz | 3 Mercedes | |
| Description Bore x stroke | | | |
| H.P. / r.p.m.; r.p.m. (eng) (pro) | 3 x 220 = 660 | 3 x 260 = 780 | 6 x 300 = 1800 / 1700; 900 Fore 700 Aft. |
| DIMENSIONS (in m) | | | |
| Span | 33 | 38 | 45 |
| Length Aspect R | | | 22 |
| Height | | | 7.5 |
| Surface (in sq.m) | | | 512 |
| WEIGHT, Total | | 7,600 | 15,500 |
| " Empty | | 5,700 | 11,000 |
| Glider | | | |
| Engine Set | | | |
| Useful Load | | | |
| Fuel / Hours of Flight | | 1,900 | 4,500 |
| Maximum Speed in horizontal flight | | | |
| Climb | | | |
| Ceiling (in m) | | 3,300 | 4,500 |
| Kg/sq.m | | | 50.3 |
| Kg/HP | | | 8.6 |
| $K_X$ in horizontal flight near ground | | | |
| $K_Y^{3/2}/K_X$ max. | | | 1.8 |
| $K_Y$ maximum | | | |
| Remarks | | | Only flew after the Armistice |

Source of Information: "Zeitschrift des Vereines Deutscher Ingenieure" of January 24th, 1920.

DEUTSCHE-FLUGZEUGWERKE AT LEIPZIG

| Constructor and Type: | No.1 1915/16 | No.2 1917 |
|---|---|---|
| Description | Biplane<br>Central fuselage<br>4 engines in fuselage<br>2 lateral tractors propellers on upper wing<br>2 lateral propulsive propellers on lower wing. | |
| ENGINES<br>Constructor and Type: | 4<br>Mercedes | 4<br>Mercedes |
| Description<br>Bore x Stroke | | |
| H.P.<br>r.p.m.;r.p.m.<br>(eng) (pro) | 4 x 220 = 880 | 4 x 260 / 1450 = 1040 |
| DIMENSIONS (in m)<br>Span<br>Length Aspect R.<br>Height<br>Surface (in sq.m) | 142 | 35.3<br>21<br>6.5<br>265 |
| WEIGHT, Total<br>" Empty | 9,400<br>6,800 | 12,000<br>8,600 |
| Glider | 4,300/0.46 | 6,000/0.5 |
| Engine Set | 2,500 | 2,600 |
| Useful Load | | |
| Fuel<br>Hours of Flight | 2,600 | 3,400 |
| Maximum Speed in horizontal flight | 120 | 132 |
| Climb | 1000 in 10'<br>2000 in 25' | |
| Ceiling (in m) | 3,500 | |
| Kg/sq.m. | 57.7 | 45 |
| Kg/HP | 10.7 | 11.6 |
| $K_X$ in horizontal flight near ground: | 0.00685 | 0.00417 |
| $K_Y^{3/2}/K_X$ max. | 2.2 | |
| $K_Y$ maximum | | |
| Remarks | Was used on the Oriental front until 1917. | 6 machines were ordered by the Army. Is now being transformed for carrying 24 passengers. |

Source of Information: "Zeitschrift des Vereines Deutscher Ingenieure" of January 31st 1920.

| Constructor and Type: | A.E.G. | LINKE-HOFFMAN, BRESLAU | |
|---|---|---|---|
| | | Type 1 | Type 2 |
| Description | Biplane<br>Central fuselage<br>4 eng. in fus.<br>2 lateral tractors of 5.1 m. | Biplane<br>Central fuselage<br>4 eng. in fus.<br>2 tractors | Biplane<br>Central fuselage<br>4 eng. in fus.<br>working 1 tractor of 6.9 m. |
| ENGINES<br>Constructor and Type: | 4<br>Mercedes | 4<br>Mercedes | 4<br>Mercedes |
| Description<br>Bore x Stroke | | | |
| H.P.<br>r.p.m.;r.p.m.<br>(eng) (pro) | 4 x 260 =1040<br>1450;750 | 4 x 260 = 1040<br>1450;750 | 4 x 260 = 1040<br>1450;750 |
| DIMENSIONS (in m)<br>Span<br>Length Aspect R<br>Height<br>Surface (in sq.m) | <br>36<br>9,5<br><br>260 | <br>33.2<br>15.6<br>6.7<br>265 | <br>42<br>20.3<br>7.1<br>320 |
| WEIGHT, Total<br>" Empty | 12,700<br>9,000 | 11,200<br>8,000 | 12,090<br>8,000 |
| Glider | | | |
| Engine Set | | | |
| Useful Load | | | |
| Fuel<br>Hours of Flight | 3,700 | 3,200 | 4,000 |
| Maximum Speed in horizontal flight | | 129 | 129 |
| Climb | | | |
| Ceiling (in m) | | 3,000 | 4,000 |
| Kg/sq.m | 49 | 42.3 | 37.8 |
| Kg/HP | 12.2 | 10.8 | 11.2 |
| $K_X$ in horizontal flight near ground | | | 0.00364 |
| $K_Y^{3/2}/K_X$ max. | | | 2.3 |
| $K_Y$ maximum | | | |
| Remarks | | Both airplanes met with accidents before conclusive results were obtained | |
| Source of Information: | Z des V.D.Ing: 7/1/1920 | "Flight" 2nd Dec. 1919. | |

ZEPPELIN WORKS AT LINDAU

DORNIER SEAPLANES

| Constructor and Type | Rs.I 1915 | Rs.II 1915/1916 |
|---|---|---|
| Description | Biplane with W shaped masts Hull fuselages 3 engines and 3 tractors in line. | Monoplane with small wings on the hull. Central hull with fuselage not fabric-covered. First 3 eng. in hull and 3 propulsive propellers in line; then 4 engines in tandem between upper wing and hull. |
| ENGINES | 3 | |
| Constructor and Type | Maybach | Maybach |
| Description | | |
| Bore x Stroke | | |
| H.P. / r.p.m.; r p.m. (eng) (pro) | 3 x 240 = 720 | 4 x 240 = 960 |
| DIMENSIONS (in m) | | |
| Span | 43.5 | 33 |
| Length Aspect R | 29 | 24 |
| Height | 7.2 | 7.6 |
| Surface (in sq,m) | 329 | 257 |
| WEIGHT, Total | | 9,100 |
| " Empty | | 7,100 |
| Glider | | |
| Engine Set | | |
| Useful Load | | |
| Fuel / Hours of Flight | | 2;000 |
| Maximum Speed in horizontal flight | | |
| Climb | | |
| Ceiling (in m) | | |
| Kg/sq.m. | | 37.7 |
| Kg/HP | | 9.75 |
| $K_X$ in horizontal flight near ground | | |
| $K_Y^{3/2}/K_X$ max | | |
| $K_Y$ maximum | | |
| Remarks | Metallic construction. | Steel and duraluminum. |

Source of Information: Z des V.D.Ing. 7/11 1920.

ZEPPELIN WORKS AT LINDAU

DORNIER SEAPLANES

| Constructor and Type | Rs. III 1917 | Rs.IV 1918 |
|---|---|---|
| Description. | Monoplane hull Fuselage at height of wings. 4 engines in tandem Steel longerons Duraluminum ribs " hull. | Monoplane hull Fuselage at height of wings 4 propellers in tandem. |
| ENGINES Constructor and Type | | 4 Maybach |
| Description Bore x Stroke | | |
| H.P. / r.p.m.;r.p.m. (eng) (pro) | 4 x 260 = 1040 | 4 x 260 = 1040 |
| DIMENSIONS (in m) | | |
| Span | 37 | 37 |
| Length Aspect R. | 25 | 22 |
| Height | 8 | 8.6 |
| Surface (in sq.m) | 226 | 226 |
| WEIGHT, Total | 10,670 | 10,500 |
| " Empty | 7,200 | 7,000 |
| Glider | | |
| Engine Set | | |
| Useful Load | | |
| Fuel / Hours of Flight | 3,470 | 3,500 |
| Maximum Speed in horizontal flight | | |
| Climb | | |
| Ceiling (in m) | | |
| Kg/sq.m | 47.1 | 46.5 |
| Kg/HP | 10.2 | 9.7 |
| $K_X$ in horizontal flight near ground | | |
| $K_Y^{3/2}/K_X$ max. | | |
| $K_Y$ maximum | | |
| Remarks | Is still used in the Navy | Intended for carrying 20 passengers |

Source of Information: Z. des V.D.Ing. 7/11 1920